IMAGING RESOURCES FOR THE GTC: IPHAS

Antonio Mampaso[1] and Romano L.M. Corradi[2]

RESUMEN

IPHAS es un cartografiado profundo y totalmente fotométrico del plano galáctico norte en Hα que se está llevando a cabo con el telescopio Isaac Newton, en La Palma. El catálogo de fuentes puntuales de IPHAS (completo hasta la magnitud r=19.5) representa un valioso recurso para el GTC en programas de investigación relacionados con fases evolutivas rápidas e importantes, pero aún mal conocidas: las estrellas pre- y post-secuencia principal, las estrellas más masivas, las binarias, etc. IPHAS posibilitará también un mejor conocimiento de la demografía de objetos extensos (nebulosas planetarias, regiones HII, restos de supernova, objetos H-H, etc.) eliminando los sesgos producidos por muestras incompletas o por objetos peculiares.

ABSTRACT

IPHAS is a deep, fully photometric Hα survey of the northern Galactic plane carried out with the Isaac Newton telescope at La Palma. The IPHAS point source Hα catalogue (complete up to r=19.5 mag) will be a prime source for GTC programs related to important short-lived (and poorly known) stages of evolution: pre- and post-main sequence stars, the most massive stars, binary stars, etc. IPHAS will also allow good demography of Hα extended nebulae (PNe, HII regions, SNR, H-H objects) avoiding biases from incomplete samples or pathologic objects.

Key Words: **GALACTIC PLANE — Hα EMISSION — ISM — PLANETARY NEBULAE**

1. THE IPHAS SURVEY

The INT Photometric Hα Survey (IPHAS; see http://astro.ic.ac.uk/Research/Halpha/North/) is mapping 1850 square degrees of the Northern Galactic plane (a band between $-5^\circ \leq l^{II} \leq +5^\circ$) using the Wide Field Camera of the 2.5m Isaac Newton telescope at the ORM (La Palma, Spain). The survey is an international collaboration among 13 institutes led by J. Drew at Imperial College (London, UK). IPHAS started in August 2003 and ends October 2006, with an estimated total of 30 observing weeks (mostly bright nights) shared by the three communities involved, UK, Spain and the Netherlands. A narrow-band Hα and two Sloan r, i filters are used for matched 120, 30, and 10 s exposures (resp.), spanning the magnitude range $13 \leq R \leq 19.5$ for point sources. As for extended emission, a completeness limit of $\log F(H\alpha) = -16.7\ erg/arcsec^2\ cm^2\ s$ is achieved.

Pipeline data reduction is performed at the ING and data distribution is handled by the Cambridge Astronomical Survey Unit (CASU; http://archive.ast.cam.ac.uk/). The data is immediately available to all astronomers from UK, Spain and the Netherlands and will be available to all astronomers after one year from the date of observing.

IPHAS is the first fully-photometric Hα survey of the Galactic plane and will complement the recently completed photographic survey of the southern Galactic plane performed with the AAO UK Schmidt Telescope (http://www-wfau.roe.ac.uk/sss/halpha/index.html). IPHAS will discover around 50000 new emission-line stars, including young stars (T Tau, Herbig AeBe stars, etc.), evolved ones (post-AGB, LBVs, etc.) as well as binaries (CVs, symbiotic stars, etc.) in addition to thousands of extended nebulae such as planetary nebulae (PNe), H-H objects, HII regions, SN remnants, etc.

At the time of writing, around 25% of the survey has been completed, yielding more than 20 million sources identified, flux calibrated and catalogued. More than 1500 new objects showing very strong Hα emission have been found.

2. PLANETARY NEBULAE FROM THE IPHAS SURVEY

We estimate that IPHAS will uncover around 700 new PNe, mostly of low surface brightness, adding to the ~900 already discovered by the southern survey (Parker & Phillipps, 2003) and more than tripling the total number known in the surveyed area. This is a substantial improvement since the Strasbourg

[1]Instituto de Astrofísica de Canarias, 38200 La Laguna, Tenerife, Spain.

[2]Isaac Newton Group of Telescopes, Ap. de Correos 321, 38700 Sta. Cruz de la Palma, Spain.

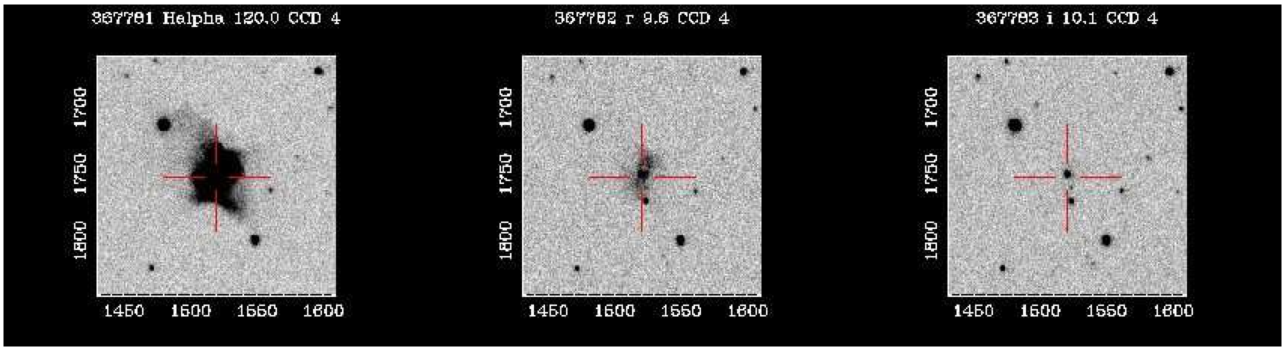

Fig. 1. The first planetary nebula discovered by IPHAS. Images are 1 arcmin on each side; North is up and East to the left.

(CDS) catalogue of galactic PNe, the most complete covering both hemispheres, lists a total of 1185 PNe. Figure 1 presents the IPHAS images of the first PN discovered during the survey. Its preliminary identification is PN G126.62+1.32; it is located at RA(2000)= 01^h 25^m 08^s; Dec(2000)= $+63°$ $56'$ $52''$ and has been confirmed spectroscopically with the WHT+ISIS. It is apparently a quadrupolar nebula, a rather unusual class of PNe showing two pairs of bipolar lobes (Manchado et al., 1996).[3]

There are several programs that could benefit from the future IPHAS PNe database. Firstly, the low nebular surface brightnesses of a large number of extended PNe that are expected to be discovered by IPHAS will make studies of their central stars easier to carry out, ultimately enabling much better statistics to be obtained on the overall incidence of binarity, the frequency of different binary types, the fraction of hydrogen-deficient nuclei (WR and PG1159-type), and the relation of the above to descendant white dwarf subtypes and to the morphologies of the nebulae. Secondly, the PNe demography on the Galactic plane will help to constraining the total number of PNe in the Galaxy. This is a poorly-known but important quantity, related to the total luminosity of the progenitor stellar population through basic (and also poorly-known) parameters like the "specific evolutionary flux" and the lifetimes of each evolutionary stages (Renzini & Buzzoni, 1986). Its dependence with other parameters like age and metallicity of the stellar population is basically unknown, although there are recent theoretical predictions (Buzzoni & Arnaboldi, 2004) and observational data (Magrini et al. 2003) suggesting that PNe formation rates do indeed depend on those parameters.

The deep and systematic search for PNe provided by IPHAS will also impact on our knowledge of the earlier and later stages of the PNe dynamic evolution: the young, compact PNe and the very extended, old nebulae.

2.1. *Compact PNe*

The detection and study of compact PNe is difficult: the whole CDS catalogue lists only nineteen objects with measured diameters between 0.5 and 2 arcsec. Albeit scarce, compact PNe are important links between AGB stars and PNe, in the fast transformation stage from spherical AGB envelopes to axi-symmetric pre-PNe. Puzzling results emerge from the few published works: e.g. Sahai and Morris (2003) imaged with the *HST* a dozen bright compact objects selected from the CDS catalogue, finding aspherical and multipolar morphologies, exciting stars displaced from the PN center, enigmatic circular rings of (very faint) emission, etc., all suggesting a sample perhaps biased by peculiar objects. IPHAS will provide a new database of compact nebulae, much more numerous and essentially bias-free. Figure 2 shows the IPHAS colour-colour plot for point sources catalogued so far and showing strong Hα emission (a cut below $H\alpha - r = -1$ has been applied). It is apparent the large number of candidates identified, several thousands in the plot. Although most of them will probably be emission-line stars, many new compact PNe can be buried in the diagram. Matching with other catalogues (*IRAS*, *MSX*, 2MASS, SIMBAD, etc.) is actually in progress to help target mining for follow-up spectroscopic identification and study.

2.2. *Evolved PNe*

Large, low surface brightness PNe are important because the studies of their central stars are less affected by contamination from the nebular gas, and

[3] The new planetary nebula has been dedicated by the IAC to the Spanish Príncipes de Asturias on the occasion of their wedding, who took place in Madrid on May, 22nd, 2004, at about the same time when the nebula was discovered.

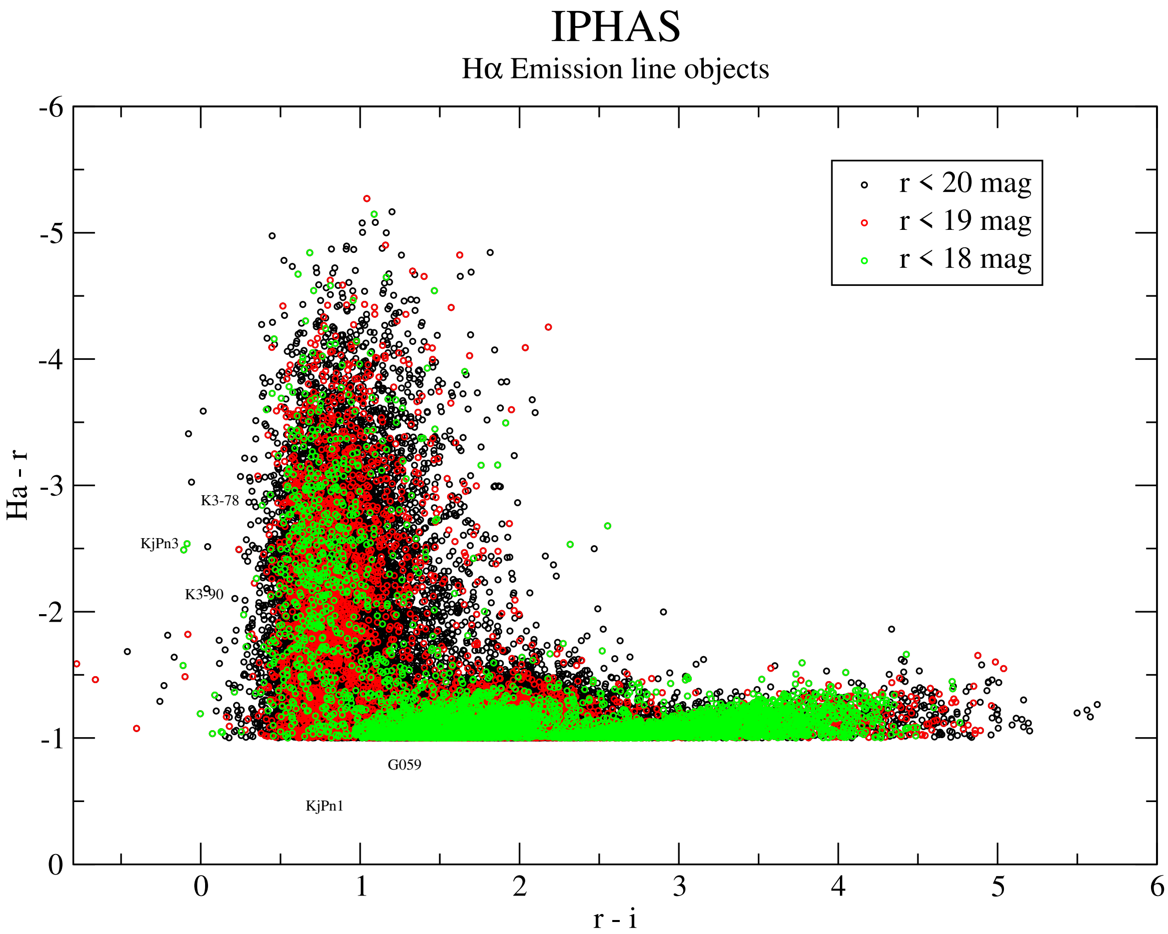

Fig. 2. Compact objects with strong Hα emission in the IPHAS colour–colour diagram. The positions of five known compact PNe are shown. The figure is in colour in the on-line journal.

also because they are useful benchmarks to study the interaction between the expanding nebular shell and the interstellar medium. The sample of very large PNe (i.e. evolved and/or nearby) is small: only 27 objects, with diameters larger than 8 arcmin, are listed by Tweedy & Kwitter (1996). Most of them are round nebulae (two thirds of the sample), a striking fact since round PNe are in general rather scarce: only around 20% of all PNe are round according to Manchado (2003). Round PNe are intrinsically different from elliptical and bipolar objects, because their chemical abundances indicate less processing of Helium, Nitrogen and Carbon (they would originate from lower mass progenitors; a recent review is given by Mampaso, 2004). This may imply a serious bias in the actual sample of evolved nebulae. Large, non-spherical PNe do indeed exist, like the huge (4 pc!) bipolar PN discovered by Corradi et al. (1997) but are difficult to find. IPHAS has the potential of practically eliminating the biases by its completeness and sensitivity. A program of visually searching for faint, very extended Hα nebulosities on the IPHAS images has been recently started, following a similar study carried out with the southern survey data (Parker et al. 2003).

3. THE GTC AND IPHAS

IPHAS will provide with many new Hα emission objects on the northern Galactic plane. Most will be very faint, either intrinsically faint, like low-mass stars, or very distant, or very reddened. Researching through this new and deep window onto the Galaxy requires spectroscopic studies of individual objects with large telescopes. The GTC may have a leading role on a variety of astrophysical programs using the IPHAS database.

In the case of PNe, deep spectra are required to measure the faint diagnostic lines, e.g. [OIII] 4363 Å and [NII] 5755 Å necessary to determine the gas temperature and the chemical abundances (see discussion in Corradi & Mampaso, this volume). Going fainter means reaching, for instance, the anticenter region, and exploring it up to very large galactocentric distances where chemical abundances of some elements (those that do not vary during the evolution of low- and intermediate-mass stars) testify how low the abundances can fall at the boundaries of the Galaxy. That, and the related abundance gradient, are critical parameters for models of galactic chemical evolution (c.f. Allen et al. 1998) but are still rather poorly-known (see, for instance, the recent review by Stasinska, 2004).

A variety of other frontier science programs will also be opened, ranging from young stars and cataclysmic variables to giant supernova remnants. The GTC community is encouraged to keep an eye on the nearby, but deep Universe, through IPHAS.

We thank the IPHAS collaboration members for continuing stimulating discussions, the ING staff for their support during so many observing nights at the INT, and Robert Greimel for making the plot in Figure 2. Funding from the Spanish AYA2002-0883 grant is also acknowledged.

REFERENCES

Allen C., Carigi L., & Peimbert M. 1998, ApJ, 494, 247

Buzzoni A., & Arnaboldi M. 2004, in Planetary Nebulae beyond the Milky Way, ESO, (to appear)

Corradi, R. L. M., Villaver, E., Mampaso, A., & Perinotto, M. 1997, A&A, 324, 276

Magrini, L., et al. 2003, A&A, 407, 51

Mampaso, A. 2004, in Asymmetrical Planetary Nebulae III, ASP Conf. Proc. (in press)

Manchado, A. 2003, IAU Symp. 209 p. 431

Manchado, A., Stanghellini, L. & Guerrero, M. 1996, ApJL, 466, 95

Parker, Q. A., & Phillipps, S. 2003, ASP Conf. Proc., 289, 165

Parker, Q. A. et al. 2003, IAU Symp. 209 p. 41

Renzini A., & Buzzoni A. 1986 in Spectral Evolution of Galaxies, Ap. Space Sci. Lib., 122, p. 195

Sahai, R., & Morris, M. 2003, Rev. Mexicana Astron. Astrofis., 15, 17

Stasinska, G. 2004, XII Canary Islands Winter School on Astrophysics. Cambridge University Press.

Tweedy, R. W., & Kwitter, K. B. 1996, ApJSS, 107, 255

R.L.M. Corradi: Isaac Newton Group of Telescopes, Ap. de Correos 321, 38700 Sta. Cruz de la Palma, Spain
e-mail: rcorradi@ing.iac.es.
A. Mampaso: Instituto de Astrofísica de Canarias, 38200 La Laguna, Tenerife, Spain
e-mail: amr@ll.iac.es